

Type 1 AGN Unification

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Abstract. The model I recently proposed for the structure of quasars offers to unify the many aspects of Type 1 AGN: emission lines, absorption lines and reflection features. This makes the model heavily overconstrained by observation and readily tested.

Here I first outline the model, and then concentrate on how the model answers objections raised since publication - with many of the tests being reported at this meeting. I then begin to explore how these and future tests can discriminate between this wind model and 3 well-defined alternatives.

1. Introduction

Just over 15 years ago AGN research made a major advance when type 2 (narrow line) AGN were clearly identified as type 1 (broad line) AGN viewed along a special, obscured, direction. This unification of type 2 AGN with their unobscured cousins brought a new degree of order and physical interpretation to the, then recklessly multiplying, ‘types’ of AGN, and a sense of the importance of non-spherical geometry in these distant unresolved objects.

Quasar research is still cursed with an overabundance of phenomenology, even after ‘type 2 unification’. The strong continuum of type AGN has imprinted on it many different features that encode aspects of the intimate environment of the nucleus: narrow, broad and ‘very broad’ emission lines, narrow intermediate (‘mini-BAL’) and broad absorption lines, X-ray warm and cold absorbers, optical/UV scatterers, X-ray reflection and fluorescence features. Unification of these details at all wavelengths into a coherent picture has been little attempted, and physics based explanations that include more than one component are rare. As a result of the baffling richness of their phenomenology quasars have become an unstimulating field for most astronomers.

However stars were in a similar situation for at least 20 years (c.1890-1911, Lawrence 1987). In fact the spectroscopic definitions of the stellar types (O B A F G K M) read quite as confusingly to outsiders as those of AGN classifications (e.g. G stars: “CaII strong; Fe and other metals strong; H weaker”, Allen 1975). We now know that the main sequence is a simple temperature progression, determined fundamentally by stellar mass. There is hope that the complexities of quasars will resolve themselves the same way. Using a 2-phase wind with a particular geometry, I have proposed (Elvis 2000) a geometrical and kinematic model for quasars that appears to subsume a great deal of the phe-

nomenology of quasar emission and absorption lines into a single simple scheme, that is not without physical appeal.

Type 2 unification demonstrated that Quasars, unlike stars, are not spherical. (In fact we have known that axisymmetry is appropriate since the first double radio sources were discovered (Jennison & Das Gupta 1953). This means that geometry matters, and when this is the case the physics cannot be worked out until we get the structure right: the solar system simply could not be solved in a Ptolemaic geometry. A normal sequence in constructing a physical theory is to work out the right geometry, then the kinematics and lastly the dynamics (c.f. Copernicus - Kepler - Newton). In quasars instead, I believe that the physics has largely already been worked out, but discarded because the geometry was not in place, making the physics appear wrong. Axisymmetry is a crucial part of type 1 unification.

Here I briefly outline the model, and then concentrate on the main objections that have been raised and respond to them. Since a model needs tests, and tests have to point to an alternative to be strong, I have begun to explore alternative wind geometries to see how their predictions differ from my model.

2. A Structure for Quasars

Winds are increasingly recognized as a common, perhaps ubiquitous, feature of quasars and AGNs. Outflows at $\sim 1000 \text{ km s}^{-1}$ are directly seen in absorption in half of all AGN (Hutchings et al. 2001, Kriss 2001, Crenshaw & Kraemer 1999, Reynolds 1997), while the much faster, $\sim 5000\text{--}10,000 \text{ km s}^{-1}$, winds of Broad Absorption Line (BAL) quasars must be present in much more than the observed 10% of quasars, since the strongly polarized emission in the BAL troughs (Ogle 1997) requires a highly non-spherical structure.

In Elvis (2000) I proposed that a flow of warm ($\sim 10^6 \text{ K}$) gas rises vertically from a *narrow range of radii* on an accretion disk. This flow then accelerates, angling outward (most likely under the influence of radiation pressure from the intense quasar continuum) until it forms thin conical wind moving radially (figure 1). When the continuum source is viewed through this wind it shows narrow absorption lines (NALs) in both UV and X-ray (the X-ray ‘warm absorber’); when viewed down the radial flow the absorption is stronger and is seen over a large range of velocities down to $v(\textit{vertical})$, the ‘detachment velocity’, so forming the Broad Absorption Line (BAL) quasars. Given the narrowness of the vertical flow ($\sim 0.1r$), the divergence of the continuum radiation at the turning point will be $\sim 6^\circ$, giving 10% solid angle coverage, and so the correct fraction of BAL quasars. [The angle to the disk axis, 60° , is at present arbitrarily chosen to give the correct number of NAL and non-NAL quasars.]

This ‘Warm Highly Ionized Gas’ (WHIG¹) has a cool phase (like the ISM) with which it is in pressure equilibrium. This cool phase provides the clouds that emit the Broad Emission Lines (BELs). Since the BEL clouds move along with the WHIG they are not ripped apart by shear forces; and since the

¹Initially I used ‘WHIM’ (i.e. ‘medium’ instead of ‘gas’) but this acronym has also been used for the ‘Warm-Hot Intergalactic Medium’ (Cen & Ostriker 1999), forcing me to adopt WHIG instead.

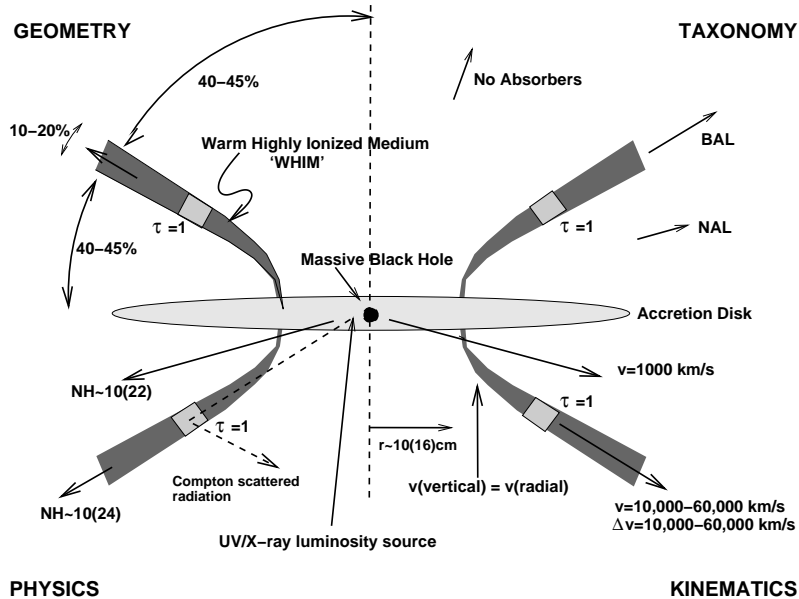


Figure 1. A Structure for Quasars (Elvis 2000).

medium is only Compton thick along the radial flow direction rapid continuum variations are not smeared out. Both problems had long been a strong objections to pressure confined BEL clouds, but they are invalid in the proposed geometry.

The radial flow is Compton thick along the flow direction, and so will scatter all wavelengths passing along that direction. Since the flow is highly non-spherical the scattered radiation will be polarized. The solid angle covered by the radial flow is 10%-20%, so this fraction of all the continuum radiation will be scattered, leading to the filling in of the BAL troughs, and to an X-ray Compton hump in all AGN. Since the WHIM is only ionized to FeXVII, there will be Fe-K fluorescence off the same structure at ~ 100 eV EW. Some of the BEL radiation will also pass along the flow and will be scattered off the fast moving flow, producing the polarized, non-variable 'Very Broad Line Region'.

3. Key Criticisms & Responses

Several criticisms of the Elvis (2000) model have come up more than once and bear careful consideration.

• Where are the BAL Seyferts?

BALs have not been found in HST studies of low luminosity AGN, but only in quasars. This would suggest a luminosity dependent wind velocity. How can this observation fit with the model? The simplest possibility is that *BALs are present at low L but had been missed*. To qualify as a BAL an absorption line needs to have a 'velocity spread' $> 2000 \text{ km s}^{-1}$ (Weymann et al. 1991). In fact, of 34 type 1 AGN observed with FUSE (Kriss 2001) two have an OVI absorber

with $\text{FWHM} > 2000 \text{ km s}^{-1}$. This fraction is in reasonable agreement with the expected $\sim 10\%$ fraction, given the limited statistics.

Two other explanations require that low luminosity AGN are subtly different from high luminosity AGN. e.g. their BALs may be too highly ionized. Since BALs are now known to have high ionization (Telfer et al. 1998, Ogle 1998), only a small increase in U (from $U \sim 2$ to $U \sim 6$) would remove CIV altogether (i.e. a factor > 100 reduction in CIV ion fraction, Mathur et al., 1995, fig. 4). The original suggestion of Elvis (2000) was that BAL outflows become dusty at low luminosities.

The first option is a clear favorite, as it is predicted by the model and so requires no additional free parameters. To be sure a much larger sample is needed. Fortunately a sample of 80 low luminosity AGN is planned to be observed with FUSE (Kriss 2001).

- *UV absorbers don't have sufficient column density to be the X-ray warm absorbers.*

Some analyses (Kriss et al. 1966) do find this to be the case, while others do not (Shields & Hamann 1997). However, Kaspi et al. (2001) note that this analysis is critically dependent on the (unobserved) EUV continuum. Kaspi et al. can match UV and X-ray column for NGC 3783 for a particular, well-constrained continuum form is assumed. This sensitivity is a strength, since accretion disk models predict specific EUV continuum shapes, which will be stringently tested if the X-ray/UV absorbers are the same. Moreover NLR optical coronal lines also have to have ratios that agree with this continuum shape.

More important is the observation by Arav, Korista & de Kool (2001) that, although the UV NALs *appear* to be unsaturated, the conventional curve-of-growth based analysis (Mathur et al. 1995 [MEW95], Kaspi et al. 2001) cannot apply to OVI or $\text{Ly}\alpha$. In several AGN the OVI doublet ratio and $\text{Ly}\alpha/\text{Ly}\beta$ ratio do not match the ratio of their respective oscillator strengths, as expected in the optically thin case. Instead Arav et al. show that the residual flux in the absorption line troughs must either be unobscured continuum produced through scattering back into our line of sight, or simply due to the absorbing gas not covering the whole continuum source. Overlooking this possibility is the same understandable mistake that led to BAL column densities underestimated by factors of 100-1000 for many years (Mathur, Elvis & Singh 1995, Ogle et al., 1998). In NGC 5548 Arav et al. show that the true column density of CIV is at least four times larger than a simple curve-of-growth analysis would give. Consistency with the X-ray columns is then readily achievable.

The result is a far simpler picture of AGN with only one, high ionization, absorber, and a realization that the FUSE spectra give us far more information about the geometry of quasar winds, and potentially on the shape of the continuum source, that we could have hoped.

- *The X-ray emission lines are narrower than the optical/UV BELs:*

The emission lines seen around 1 keV in *Chandra* and XMM-Newton AGN spectra have widths of $\leq 1000 \text{ km s}^{-1}$, several times narrower than the BEL widths (Krolik & Kriss 2001). They are consistent with an origin in the Narrow Line Region (Ogle et al. 2000), or the hypothesized 'donut'-shaped torus.

However BEL-shaped X-ray lines would not be detectable in the existing *Chandra* or XMM-Newton spectra because BEL widths of $\sim 3000 \text{ km s}^{-1}$ are

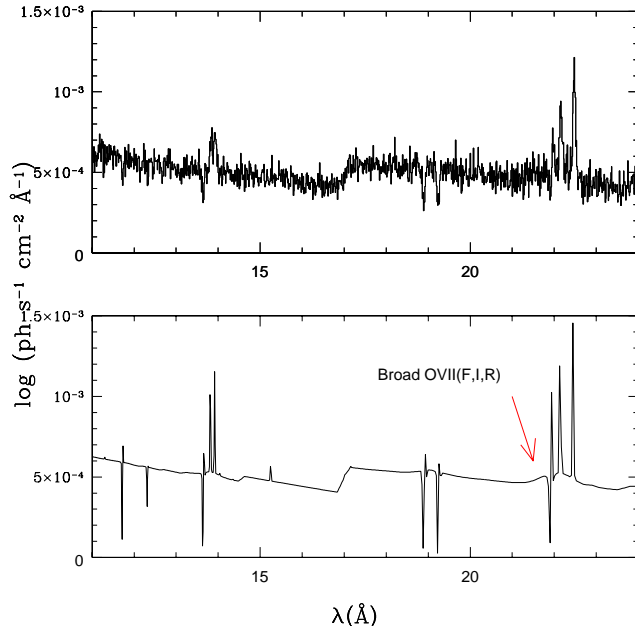


Figure 2. (a) Simulated 750 ksec *Chandra* HRC-LETGS spectrum of NGC 5548 including a BLR component ($f_C=0.1$; (b) input spectrum, the broad OVII line is marked). F.Nicastro (2001), private communication.

over-resolved in *Chandra*. Figure 2 shows a simulation of a long *Chandra* HETG spectrum with narrow X-ray emission lines from similar to those in Mrk 3 and NGC 4151 (Sako et al., 2000, Ogle et al. 2000), and broad lines matching the NGC 5548 BEL widths for a covering factor 0.1 (F. Nicastro 2001, private communication). The broad lines are not detectable.

Much longer exposures with *Chandra* could provide strong limits. The expected WHIG line profiles then need to be calculated carefully, since the WHIG is optically thin to the X-ray lines, but BEL clouds are optically thick. This means that the profiles of X-ray and optical broad lines will be different, with the X-rays probably showing a double peaked structure. This line shape also may confuse present analysis.

- *UV absorbers have multiple velocity components requiring multiple absorbing zones, probably with different ionization states.*

X-ray instrumentation is sensitive to only a limited range of column densities, while ultraviolet spectra can only detect a limited range of high ionization states. For comparable ionization states systems with column densities at least 10 times smaller than the X-ray (Kriss et al. 2000) can be detected by HST and FUSE spectra than by *Chandra* ($N_{H \min} \sim 10^{20.5} \text{cm}^{-2}$, Collinge et al. 2001), since *Chandra* is limited in both S/N and resolution (Collinge et al. 2001). High ionization absorption systems instead can only be seen in X-ray spectra, since the ion populations of the UV transitions become tiny. (e.g. the high velocity system in NGC 4051, Collinge et al. 2001.) Modest inhomogeneities in the WHIG wind could produce the needed differences in U .

It is worth recalling that the ‘single X-ray/UV absorber’ model has already passed two tests. Before the *Chandra* high resolution grating spectra it was possible that the X-ray absorbers had quite different velocities and widths to the UV absorbers. Instead the *Chandra* spectra confirmed a good correspondence between the two systems in both redshift and line width (Kaspi et al. 2001, Collinge et al. 2001), which was a strong prediction of the model. Radiatively accelerated winds seem to be inherently unstable and normally produce highly structured line profiles (e.g. P Cygni, Stahl et al. 1993). The detailed sub-structure is then ‘mere’ weather.

• *BALs are too low ionization to be due to the X-ray Warm Absorber gas.*

Indirect arguments based on the large X-ray column densities of BALs (MES95) argue for high ionization. More recently BALs have been found in the phosphorus PV ion, confirming unequivocally their high ionization, although so far only for a few quasars (Hamann et al., 1995).

Since Compton scattering is wavelength independent the BAL covering factor in the soft X-ray band should be the same as in the optical if the BAL material is sufficiently ionized. Partial covering of the right order is seen in the X-ray spectrum of one BAL quasar (Mathur et al. 2001). The low energy X-rays should also be polarized like the optical BAL troughs, an observation that may now become feasible (daCosta et al. 2001).

• *The X-ray absorbers are too far from the BELR*

The radius of the NAL from the continuum source has to match the radius of the high ionization BELR. In NGC 5548 this works, but the NAL radius is poorly constrained (a factor 100). Short recombination times, which will determine the NAL density, are the key to a better constraint on the radius. Timescales of hours are likely, and require quite large continuum variations on this timescale or less to be measurable.

There are also high ionization BELs of PVII and NeVIII now detected at $\sim 770\text{\AA}$ (rest) in some high redshift quasars (Hamann et al. 1995). These do not match normal BEL cloud conditions, but could arise from the WHIG. In this case they should match the WHIG properties. In fact Hamann et al. (1995) find values that do fit: column densities of $\sim 10^{22}\text{cm}^{-2}$, a temperature of $5 \times 10^5\text{K}$ (if collisional), and a covering factor of 0.5 like that of NALs (and unlike the BELR, for which 0.1 is a typical value).

• *Why should the wind be narrow? What ‘special’ radius could there be?*

We know that there is some physics of accretion disks that causes instabilities over a relatively narrow range of radii since QPOs in X-ray binaries have a width $\Delta\nu/\nu \sim 0.1$. If these QPOs arise in accretion disks then they have a spread in radius of the same order. So we have good evidence that special ranges of radii can exist in accretion disks, even though the physical cause is still debated, even in the case of QPOs (B. Czerny 2001, private communication).

The NALs are stable features of AGN spectra over at least 20 years (MEW95). This might have been because they lie a long way from the continuum source, but (in NGC 5548, Shull and Sachs 1993) the short CIV recombination time (< 4 days) requires a high density ($n_e > 5 \times 10^4\text{cm}^{-3}$). Given the high ionization parameter ($U \sim 1$) the absorber cannot be more than $2 \times 10^{18}\text{cm}$ from the continuum source (MEW95) and no more than $\sim 10^{16}\text{cm}$ thick. The crossing time

for a spherical blob of this radius is $10^8 M_6^{-\frac{1}{2}}$ s at 10^{18} cm, requiring a cloud elongated by at least 6:1 to be seen for 20 years, implying a length nearly 0.1 the distance from the center. A higher density cloud will be smaller and nearer the center (to maintain U) and will have shorter crossing times ($\tau_{c.cross} \propto n_e^{-\frac{5}{4}}$). The concept of obscuring clouds then morphs into that of a continuous flow with an elongation equal to the radial distance at a density ~ 40 times higher. An improved density estimate for the absorber (and hence the distance from the center), from UV or X-ray monitoring, will give a clear test.

The timescales for stochastic flares (as seen in initial simulations, e.g. Proga 2001) need to be investigated to see if they can produce stable absorbers of sufficient density over decade long timescales. If not then some more continuous injection/ejection process will be needed.

• *The BELR is not in radial motion.*

Reverberation mapping (Peterson 1997) shows that the BELR is not dominated by radial motion, either outflow or inflow. However, this is not the prediction of the model. The initial flow from the accretion disk is vertical, producing a thin cylinder that has a primarily rotational velocity at the disk Keplerian speed (see also Nicastro 1999). Laor (2001) finds that weak EW([OIII]), the presence of NALs, and width of CIV are correlated in PG quasars. If [OIII] is isotropic and the continuum is from a disk then the EW([OIII]) is an inclination indicator, and broader CIV with absorbers will be found in edge-on AGN if the BELR is disk-like or cylindrical (Risaliti, Laor & Elvis 2001, in preparation). N. Murray (2001, private communication) notes that a cylinder or disk geometry for the BELR is suggested by the observation of double-peaked profiles for CIV following a flare in NGC 5548, when the BELs may become optically thin.

A cylindrical BELR may also explain the peculiar rotation of polarization position angle of $H\alpha$ in AGN (Cohen & Martel 2001, Axon, these proceedings). BEL photons will scatter off the opposite side of the rotating cylinder. A cylinder, being hollow, is optically thin to BELR photons, allowing them to cross readily to the other side. Similar PA rotations are implied for *all* edge-on AGN, i.e. those with NALs. Axon (these proceedings) shows that AGN have two types of $H\alpha$ polarization, apparently consistent with the two main viewing angles of a cylindrical BELR. His data promise strong tests of the geometry.

• *The narrow Fe-K line comes from the torus, not a BAL wind.*

A ‘narrow’ Fe-K line is seen in most Seyfert galaxies, and this is usually ascribed an origin in the pc-scale ‘donut’-shaped torus normally employed in type2/type 1 unification models (Urry & Padovani 1995). This Fe-K line provides a strong test of the model since the BAL-producing radial outflow *must* produce Fe-K emission. This outer, conical, part of the WHIG has to be Compton thick to produce the scattered light seen in BAL troughs (Ogle 1998). Since Compton scattering is grey (wavelength independent) the same region will produce a symmetric X-ray 6.4 keV Fe-K emission line. The Fe-K line from the structure will have a width comparable to, but broader than, the BELR widths (since the wind is accelerating outward). The line should be a factor ~ 2 broader if the wind is radiatively accelerated. So the Fe-K width is likely to be correlated with the BEL widths, and will be clearly broader than the NLR-like widths as-

sociated with a ‘donut’ shaped torus, but clearly narrower than the relativistic widths that would be produced by the inner regions of an accretion disk.

Other parts of an AGN (a ‘donut’, the NELR or an accretion disk) may also produce Fe-K. High resolution X-ray spectra (e.g. with the HETGS on *Chandra*) will be able to resolve these components, and so determine whether a WHIG-related Fe-K line exists as predicted. The first Chandra HETG results seem to indicate that such fairly broad (BELR-like) components of Fe-K do exist: NGC 5548 has a resolved Fe-K line $\text{FWHM}=4525^{+3525}_{-2645} \text{ km s}^{-1}$ (90%, Yaqoob et al. 2001, c.f. $\text{H}\beta$ $\text{FWHM}=3700 \text{ km s}^{-1}$, Osterbrock 1977); while NGC 3783 has $\text{FWHM}<3250 \text{ km s}^{-1}$ (Kaspi et al., 2001, c.f. $\text{H}\beta$ $\text{FWHM}=4100\pm1160 \text{ km s}^{-1}$, Wandel et al. (1999).

Variability gives another clean cut way to discriminate between Fe-K from a pc-scale ‘donut’, BELR-related emission, and the inner regions of an accretion disk. Several studies have already shown that the ‘narrow’ Fe-K component does not vary in unison with the X-ray continuum (e.g. Chiang et al. 2000, Risaliti 2001), ruling out the accretion disk origin. A BELR-related Fe-K line would follow the X-ray continuum with a reverberation delay larger than but similar to the CIV reverberation delay. Takashi, Inoue & Dotani (2001) have found such an effect in NGC 4151. They derive an Fe-K scattering region size of 10^{17} cm which is five times larger than the CIV radius for NGC 4151 (9 ± 2 light-days, $2\times10^{16} \text{ cm}$, Kaspi et al. 1996), consistent with the proposed structure. This size is inconsistent with a pc-scale ‘donut’ origin. This is strong support for the proposed structure.

The optical/UV continuum is scattered by the structure. At any given angle there will be four dominant delay times relative to a central continuum flaring event, as the flare scatters off the near and far parts of the $\tau=1$ rings above and below the disk plane. (The disk may obscure one or both parts of the lower ring.) These should show up in autocorrelation functions of the continuum at low amplitudes. Schild (2001) has found that previously published (Schild 1986) autocorrelation timescales in the gravitational lens Q 0957+561 are consistent, in an overconstrained set of equations, with the double ring expected from this structure.

The X-ray ‘Compton Hump’ should show the same time smearing and delays as the Fe-K line. Moreover the Compton Hump should be polarized, just as the optical BAL troughs are polarized. DaCosta et al. (2001) have just demonstrated a high efficiency X-ray polarimeter. Behind a reasonable sized X-ray mirror this could make clear tests of the model.

4. Alternative Wind Models

To reconcile the presence of both a fast (BAL) wind and a slow (NAL) wind in most AGN and quasars, we adopted a single wind with a special geometry. It is worth considering alternative means of reconciling these two winds by relaxing the constraint that they are the same flow. There are two main possibilities: either high luminosity objects have faster winds, or faster winds are emitted in some preferential direction, and slower winds in others. Here we begin to examine these options. We assume that the models retain all the other features of our model. I.e. they still try to combine the UV and X-ray absorbers in a

single WHIG (our starting point); and they have the BEL clouds embedded in this wind; they try to explain reflection features via scattering off the fast wind.

4.1. Luminosity Dependent Velocities

In this hypothesis the fast BAL winds are emitted only by high luminosity quasars (into a $\sim 10\%$ solid angle), while NAL winds are found only at lower luminosities (for a $\sim 50\%$ solid angle). The wind no longer needs to arise from a narrow range of disk radii.

There are a number of comments that can be made:

- (1) In this scenario a continuum of widths should be found with a covering factor that decreases from $\sim 50\%$ at NGC 5548 luminosities ($L_X \sim 5 \times 10^{43} \text{ erg s}^{-1}$, Elvis et al., 1978), to $\sim 10\%$ at $L_X \sim 10^{46} \text{ erg s}^{-1}$ PHL 5200, MES95). There is a range of BAL velocities, but a line width vs. luminosity or covering factor analysis has not yet been performed.
- (2) This model has a built-in explanation for the absence of low luminosity BALs.
- (3) This model has no obvious physical cause for a BAL ‘detachment velocity’.
- (4) Can high ionization BELs with large covering factor arise in this model?
- (5) The scattering effects of the radial part of the wind (X-ray Fe-K emission line, Compton hump, optical polarized flux) will disappear in lower luminosity objects since the column density needed to produce scattering is much larger than the column density through the X-ray warm absorbers, and low luminosity AGN will have no fast wind out of the line of sight to produce the polarized, non-variable ‘Very Broad Line Region’. The opposite is observed (Iwasawa & Taniguchi 1993).
- (6) The BAL opening angle of 10% does not arise naturally from the narrow width of the wind origin site on the disk.
- (7) Are there directions in which one looks through the wind? If so then NALs will be seen, the wind originates from a restricted range of radii and the picture reverts to something close to our model.

The absence of reflection effects in this version considerably weakens its unifying power.

4.2. Orientation Dependent Velocities

In this hypothesis the quasar wind has fast (BAL) velocities only in some directions (covering $\sim 10\%$ solid angle), and has slower (NAL) velocities in other directions (covering $\sim 50\%$ solid angle). There are two obvious preferential directions for the fast wind: *polar* and *equatorial* (figure 3).

Some comments are:

- (1) Proga (these proceedings) finds such a directional velocity stratification arising naturally from his simulations, with higher velocities toward the pole (figure 3b).
- (2) Like our model, this hypothesis does not explain the absence of low luminosity BALs, but they may in fact exist (see §3).
- (3) Again, this model has no obvious physical cause for a ‘detachment velocity’.
- (4) Compton scattering features will arise naturally in all objects in this model, as in ours, if the fast wind has sufficient column density.

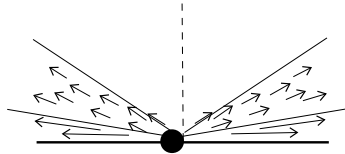
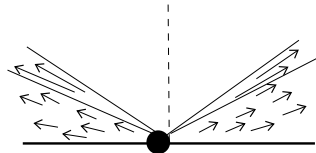
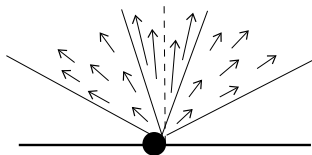
(a) *Fast Equatorial:*(b) *Fast Polar I:*(c) *Fast Polar II:*

Figure 3. Options for quasar winds with direction dependent velocities.

(5) The fast wind has to have a large column density of high velocity material when viewed end-on to reproduce the BAL observations. This arises naturally in our model, but is not obvious in this hypothesis. A large column density implies a large mass input rate at the wind base, decaying rapidly to larger radii (in the fast polar case; to smaller radii for the fast equatorial case).

(6) In the fast polar case a much ($<1\%$) lower column density is required when viewed from other directions to avoid BALs being seen more often. A long thin BAL region is necessary, which would have to be non-divergent to maintain column density. This may make it difficult to cover a 10% solid angle. An equatorial fast wind avoids this problem.

(7) An equatorial fast wind has the faster material originating further from the continuum source, which seems unlikely since radiation pressure and Keplerian rotation both predict the opposite. A polar fast wind avoids this problem.

The difficulties in this version of the model lie primarily in theory: can the large column densities needed in the fast wind be produced, in an acceptable geometry? Neither the polar nor equatorial solution is fully appealing.

5. Conclusions

Because the Elvis (2000) model unifies so many aspects of Type 1 AGN phenomenology it is highly overconstrained, and so readily tested. This is a strength of the model. The model has passed quite a number of tests already, but they are not yet as stringent as one would like.

Quite simple extensions of the model (e.g. to type 2 objects, Risaliti, Elvis, & Nicastro 2001) suggest that much more of the quasar/AGN phenomenology can be incorporated with only a handful of extra variables. Consideration of the

fate of the quasar wind, which clearly exceeds the escape velocity of any galaxy or cluster of galaxies, should also be illuminating (e.g. Elvis, Marengo & Karovska 2001). With luck then, quasars will now enter a period of rapid development of their physics (e.g. Nicastro 2000), allowing their physical evolution to be understood, and placing them constructively within cosmology.

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